Chapter 1

Introduction

What is the *National Sediment Quality Survey*?

The Water Resources Development Act (WRDA) of 1992 directed the U.S. Environmental Protection Agency (EPA), in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE), to conduct a comprehensive national survey of data regarding the quality of sediments in the United States. Section 503 of WRDA 1992 requires EPA to "compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in aquatic sediments, including the probable sources of such pollutants and identification of those sediments which are contaminated...." Section 501(b)(4) of WRDA 1992 defines "contaminated sediment" as "aquatic sediment which contains chemical substances in excess of appropriate geochemical, toxicological or sediment quality criteria or measures; or is otherwise considered by the Administrator [of EPA] to pose a threat to human health or the environment...." Section 503 further requires EPA to "report to Congress the findings, conclusions, and recommendations of such survey, including recommendations for actions necessary to prevent contamination of aquatic sediments and to control sources of contamination." As part of this continuing program, EPA must report to Congress every 2 years on the assessments findings of the assessment.

To comply with this mandate, EPA's Office of Science and Technology (OST) initiated the National Sediment Inventory (NSI) database. The goals of the NSI are to compile sediment quality information from available electronic databases, develop screening-level assessment protocols to identify potentially contaminated sediment, and produce biennial reports to Congress as well as the regions, states, and tribes on the incidence and severity of sediment contamination nationwide. To ensure that future reports to Congress accurately reflect the latest conditions of the Nation's Sediment as science evolves, the NSI database will develop into a regularly updated, centralized aggregation of sediment quality measurements.

In 1997, EPA published the first report entitled, *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States*, volumes 1 - 3. The first volume, *Volume 1: The National Sediment Quality Survey* (USEPA, 1997), presented a national baseline screening-level assessment of contaminated sediments from sediment quality data collected from 1980 through 1993 using a weight-of-evidence approach. The purpose of the initial *National Sediment Quality Survey* as well as this first update to that report is to depict and characterize the incidence and severity of sediment contamination based on the *probability* of adverse effects to human health and the environment, and the information outlined could be used to further investigate sediment contamination on a national, regional, and site-specific scale. Volume 2 of the first report presented data summaries for watersheds that were identified as containing areas of probable concern for sediment contamination and Volume 3 presented a screening analysis to identify probable point source contributors of sediment pollutants.

For this current *National Sediment Quality Survey*, OST added to the data compiled in the initial NSI database with additional data from across the country currently stored in large electronic databases and covering the years up to 1999. This effort required a substantial synthesis of multiple formats and the coordinated efforts of many federal and state environmental information programs that maintain relevant data. Data from many sampling and testing studies have not yet been incorporated into the NSI database and therefore not evaluated in this *National Sediment Quality Survey*. Thus, it is highly likely that additional locations ranging from relatively pristine to extensive sediment contamination do not appear in the NSI and are therefore not evaluated in the *National Sediment Quality Survey*. As data management systems and access capabilities continue to improve, EPA anticipates that a greater amount of data will be incorporated in the NSI and subsequent *National Sediment Quality Survey* reports to Congress.

This report presents the results of the screening-level assessment of the NSI data from 1990 to 1999. For this assessment, OST examined sediment chemistry data, tissue residue data, and sediment toxicity test results. The purpose of this assessment was to determine whether potential adverse effects from sediment contamination either exist currently or existed over the past 10 years at distinct monitoring locations throughout the United States. The initial *National Sediment Quality Survey* report to Congress used all the data available from 1980 to 1993 for developing a baseline assessment. Due to the biennial reporting requirements associated with this report, EPA wanted to 'window in' on a regular time frame for including data. One major advantage of screening out older data (data collected prior to January 1, 1990) is to prevent the results presented in this report from being unduly influenced by historical data when more recent data are available. This would not allow the results of any decrease in sediment contaminant levels due to scouring, re-burial, natural attenuation, or active sediment remediation that have occurred since that sample was collected.

This report identifies locations where available data indicate that direct or indirect exposure to the sediment could be associated with adverse effects to aquatic life and/or human health. Even though this report focuses on data collected from 1990 through 1999, conditions might have improved or worsened since the sediment was sampled. Additionally, the data were generally not collected in a randomized sampling approach. Consequently, this report does not and can not provide a definitive assessment of the national condition or relative health of sediments across the country. Even though this report does not provide an assessment of the "national condition" of contaminated sediments it does evaluate data from 1980 through 1999 in the NSI database to assess changes in the extent and severity of sediment contamination over time for specific areas in the United States where sufficient data exists.

This *National Sediment Quality Survey* and future iterations of this report will provide environmental managers at the federal, state, and local levels with valuable information. The NSI database and this report can assist local watershed managers by providing additional data that they may not have, demonstrating the application of a weight-of-evidence approach for identifying and screening contaminated sediment locations. It also allows researchers to draw upon a large data set of sediment information to conduct new analyses that will continue to advance the science of contaminated sediment assessments that can ultimately be applied at the local level to assist environmental managers in making sediment management decisions.

This *National Sediment Quality Survey* provides a screening-level assessment of data collected from 1990 to 1999 and contained in the NSI database. Chapter 1 provides the intent of this report and background information on sediment quality issues. Chapter 2 is an overview of the assessment methodology used to evaluate the NSI data (from 1990 through 1999) to identify potentially contaminated sediment locations. Chapter 3 contains the results of the evaluation on a national, regional, and state level. Chapter 4 presents the methods used and the results of a temporal trend analysis of sediment contamination over time. Chapter 5 discusses general remediation considerations. Chapter 6 provides a discussion of the results. Recommendations for evaluating and managing contaminated sediments are outlined in Chapter 7. Several appendices represent detailed descriptions of both the data within the NSI database and the approaches used to evaluate the data. These appendices are:

Appendix A: National Sediment Inventory Field Description

Appendix B: Description of Evaluation Parameters Used in the NSI database Evaluation

Appendix C: Values Used for Chemicals Evaluated

Appendix D: Species Characteristics Related to NSI Bioaccumulation Data

Appendix E: Trend Analysis Case Studies

Why is Contaminated Sediment An Important National Issue?

In response to the need for National guidance on addressing contaminated sediments EPA released it's Contaminated Sediment Management Strategy in 1998. This document established four goals to manage the problem of contaminated sediment, and describes actions the Agency intends to take to accomplish those goals. The four goals are: 1) Prevent the volume of contaminated sediment from increasing; 2) Reduce the volume of existing contaminated sediments; 3) Ensure that sediment dredging and dredged material disposal are managed in an environmentally sound manner, and; 4) Develop scientifically sound sediment management tools for use in pollution prevention, source control, remediation, and dredged material management.

Contaminated sediment poses ecological and human health risks in many watersheds throughout the United States. It has been shown in areas where USEPA Water Quality Criteria (WQC) are not exceeded that adverse effects have been observed in organisms in or near the sediments (Chapman, 1989). Since many chemicals of anthropogenic origin [e.g., pesticides, polycyclic aromatic hydrocarbons (PAHs), and chlorinated hydrocarbons] tend to sorb to sediments and organic materials, these chemicals also end up concentrating in the sediment which acts as a reservoir. Although concentrations of chemicals in sediment may be several orders of magnitude higher than in the overlying water, bulk sediment concentrations have not been strongly correlated to bioavailability (Burton, 1991). Nevertheless, sediment contamination can have many detrimental effects on an ecosystem, some of which are evident and others more discrete or unknown. For example, benthic invertebrate communities can be totally lost or converted from sensitive to pollution-tolerant species. These tolerant species process a variety of materials, and their metabolic products may also be different. These differences mean that ecosystem functions such as energy flow, productivity, and decomposition processes may be significantly altered (Griffiths, 1983). Loss of any biological community in the ecosystem can indirectly affect other components of the system. For example, if the benthic community is significantly changed, nitrogen cycling may be altered such that forms of nitrogen necessary for key phytoplankton species are lost and the phytoplankton are replaced with blue-green algae (cyanobacteria) capable of nitrogen fixation. Other effects from sediment contamination are direct, as observed in the Great Lakes where top predator fish have become highly contaminated from consuming bottom-feeding fish and benthic invertebrates that are laden with sediment-associated pollutants, such as PAHs, PCBs, mercury, and pesticides. Documented adverse ecological effects from contaminated sediments include fin rot, increased tumor frequency, and reproductive toxicity in fish as well as a decrease in aquatic ecosystem biodiversity (USEPA, 1998). Effects on ecosystem processes have been very dramatic in areas affected by both acid precipitation and acid mine drainage which contribute to waterbodies pollutant loading. However, in most areas receiving pollutant loadings, the effects are difficult to observe and require use of a variety of assessment tools, such as benthic macroinvertebrate community analyses, chemical testing, quantification of habitat characteristics, and toxicity testing (Burton and Scott, 1992).

As described above, sediment contamination can adversely affect the health of organisms and provide a source of contaminants to the aquatic food chain (Lyman et al., 1987). For example, fin rot and a variety of tumors have been found in fish living above sediments contaminated by PAHs located near a creosote plant on the Elizabeth River in Virginia. These impacts have been correlated with the extent of sediment contamination in the river (Van Veld et al., 1990). Human and wildlife consumption of finfish and shellfish that have accumulated contaminants in their tissue (bioaccumulation) is an important human health and wildlife concern. In fact, fish consumption represents the most significant route of aquatic exposure of humans to many metals and organic compounds (USEPA, 1992). Most sediment-related human exposure to contaminants is through indirect routes that involves the transfer of pollutants out of the sediments and into the water column or aquatic organisms. Many surface waters have fish consumption advisories or fishing bans in place due mostly to mercury, PCBs, chlordane, dioxins, and DDT and its metabolites (DDD and DDE) which are commonly found in sediments. Based on EPA's National Listing of Fish and Wildlife Advisories database (NLFWA) there are more than 2,800 fish advisories in the United States for the types of contaminants often found in contaminated sediments. These advisories affect over 325,000 river miles, 71% of the Nation's Coastal Waters, and more than 63,000 lakes, including 100% of the Great Lakes.

Additional examples of direct impacts of contaminated sediment on wildlife and humans have been noted. Bishop et al. (1995; 1999) found good correlations between a variety of chlorinated hydrocarbons in the sediment and concentrations in bird eggs. These researchers found that this relationship indicated that the female contaminant body burden was obtained locally, just prior to egg laying. Other studies by Bishop et al. indicated a link between exposure of snapping turtle (*Chelydra s. serpentina*) eggs to contaminants (including sediment exposure) and developmental success (Bishop et al., 1991; 1998). Other investigations of environmentally occurring persistent organics have shown bioaccumulation and a range of effects in the mudpuppy (*Necturus maculosus*) (Bonin et al., 1995; Gendron et al., 1997). In the case of humans there is only anecdotal evidence from cases like Monguagon Creek, a small tributary to the Detroit River, where incidental human contact with the sediment resulted in a skin rash (Zarull et al., 1999).

In addition to human health and ecological impacts, contaminated sediments may cause severe economic impacts. Economic risk may be felt by the transportation, tourism, and fishing industries. In one Great Lakes harbor (Indiana Harbor Ship Canal), navigational dredging has not been conducted since 1972 "due to the lack of an approved economically feasible and environmentally acceptable disposal facility for dredged materials from" the Indiana Harbor Ship Canal (USACE, 1995). The accumulation of sediment in this Canal has increased costs for industry. Ships carrying raw materials have difficulty navigating in the Harbor and Canal. In addition, ships come into the harbor loaded at less than optimum vessel drafts. There is also restricted use of various docks, requiring unloading at alternate docks and double handling of bulk commodities to the preferred dock. These problems are causing increased transportation costs of waterborne commerce in this Canal, estimated in 1995 at $12.4 million annually (USACE, 1995).

How Significant is The Problem?

In the first Report to Congress, EPA found that every state in the country had at least one sampling location that was classified as having probable adverse effects to aquatic life or human health, indicating a geographically diverse problem. Other more, geographically targeted studies have attempted to quantify the extensiveness of sediment contamination. For example, studies conducted from the Great Lakes area have demonstrated that contaminated sediments are of great concern to humans and wildlife that live within the Great Lakes Basin. Years of industrial and municipal discharges, combined sewer overflows and urban and agricultural non-point source runoff have contributed to the creation of vast amounts of highly polluted sediments that pose serious human and ecological health risks (USEPA, 2000a). Sediments have been collecting on the bottoms of the Great Lakes ever since they were formed by glacial scouring and melting. Even after cleanup efforts began in the late 1960's, little attention was paid to the toxics that accumulated in the bottom sediments. The first priority was to stop the discharge of new contaminants, and little concern was paid to sediments (USEPA, 2000a). It was not until the early 1980's that environmental problems caused by sediment contamination began to generate interest in the Great Lakes.

EPA's Great Lakes Program Office (GLNPO) identifies polluted sediment as the largest major source of contaminants in the Great Lakes food chain, including the 43 Areas of Concern (Figure 1-1). As of the year 2000, over 2,000 miles (20 percent) of the shoreline were considered impaired because of sediment contamination and fish consumption advisories remain in place throughout the Great Lakes and many inland lakes. On the U.S. side of the border, sediments have been assessed at 26 Great Lakes locations and over 1,300,000 cubic yards of contaminated sediments have been remediated over the past three years.

Figure 1-1. Areas of Concern in the Great Lakes - St. Lawrence River Basin

Numerous statutes, including the Clean Water Act (CWA), the Marine Protection, Research, and Sanctuaries Act (MPRSA or Ocean Dumping Act), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorize programs that address contaminated sediments (USEPA, 1998). First, the disposal of material resulting from navigational dredging in the Nation's waters is regulated under either the CWA (Section 404) or the MPRSA, depending on the location of the disposal site. Although it is estimated that only 5-10 percent of the material dredged each year is not suitable for open water disposal due to contamination, there are widespread concerns among the public regarding the effect of contaminated dredged material disposal. The difficulty associated with finding alternative disposal options for contaminated dredged material often results in project delays, additional costs, and significant controversy.

CERCLA provides one of the most comprehensive authorities available to EPA to obtain sediment clean-up, reimbursement of EPA clean-up costs, and compensation to natural resource trustees for damages to natural resources affected by contaminated sediments. Removal actions and enforcement actions can be brought at both National Priority List (NPL) and non-NPL sites. To date, twenty percent, or about 300 sites on the Superfund NPL appear to have some kind of contaminated sediment. EPA has made decisions at almost 50% of these sites to address that contamination. Most of these sites are small, but there are a few sites that are quite large.

In addition, under CWA Section 303(d), EPA and the states may address contaminated sediments in developing Total Maximum Daily Loads (TMDLs). TMDLs identify the loading capacity of waters not meeting water quality standards. TMDLs allocate the receiving waters' pollutant loading capacity among point and nonpoint sources of pollutants of concern. Based on the states' 1998 lists of impaired waters, about 36,000 TMDLs will need to be developed for about 20,000 impaired waterbodies throughout the United States. Based on the TMDL tracking system with the 1998 data, only 32 impaired waterbodies were specifically identified as impaired by contaminated sediments. However, about 21 percent of the TMDLs are for pollutants which are also often found in contaminated sediments (e.g., PCBs, mercury, pesticides, etc.). It is very likely that these TMDLs will require some analysis for the contribution of pollutants from contaminated sediments.

In 1994, the National Oceanic and Atmospheric Administration (NOAA) released its Inventory of Chemical Concentrations in Coastal and Estuarine Sediments (NOAA, 1994). This study characterized 2,800 coastal sites as either "high" or "hot," based on the contaminant concentrations found at the sampling locations. NOAA did not use risk-based screening values for its analysis. Using the National Status and Trends Mussel Watch data set, "high" values were defined as the mean concentration for a specific chemical plus one standard deviation. NOAA's "high" values correspond to about the 85^{th} percentile of contaminant concentration. "Hot" concentrations were defined as those exceeding five times the "high" values. Most of the "hot" sites were in locations with high ship traffic, industrial activity, and relatively poor flushing such as harbors, canals, and intercoastal waterways (NOAA, 1994). Mercury and cadmium exceeded the NOAA "hot" thresholds at a greater percentage of sites where they were measured (about 7 percent each) than other sediment contaminants (USEPA, 1998).

In selected areas throughout 25 estuaries and marine bays along the Atlantic, Gulf of Mexico, and Pacific coasts, NOAA performed toxicity tests on 1543 surficial sediment samples collected from 1991 through 1997. The toxicity of each sample was determined by exposing amphipods to bulk sediments for 10 days and measuring their survival. These 1543 samples tested through 1997 collectively represent a total area of approximately 7300 km^2. Toxicity was observed in samples that represented approximately 6% of the combined area (Long, 2000). Using similar tests conducted on samples collected in different, but overlapping, study areas, the EPA estimated that approximately 7% of the combined estuarine area sampled was toxic. The northeastern and southwestern estuaries displayed the most severe toxicity generally, and toxicity was observed the least in southeastern and northwestern areas. However, extensive portions of the Pacific coast have not been tested with the same methods. Toxicity was considerably much more widespread (25% to 39%), however, when the results of two sub-lethal sediment toxicity tests were evaluated (Long, 2000).

As part of EPA's Environmental Monitoring and Assessment Program (EMAP), sediment samples were collected to assess toxicity on a regional scale in streams and rivers in the Mid-Atlantic U.S. in 1994, 1997, and 1998 and in the Colorado Rocky Mountains in 1994 and 1995. Sample sites were selected randomly using a probability design so that the results could be extrapolated for the entire region. Toxicity was evaluated on these samples by exposing an amphipod (*Hyalella azteca*) to bulk sediment and measuring lethality and growth. In 1994, approximately 5.7% of the Mid-Atlantic stream length (10,700 km out of 188,700 km) was found to have toxic sediments. In 1997 and 1998, sediments from approximately 8.7% (21,830 km out of 250,500 km) of Mid-Atlantic stream length was found to be toxic. In the Southern Colorado Rockies, an estimated 422 km (6.4%) of the 6,600 km of target stream length had toxic sediments.